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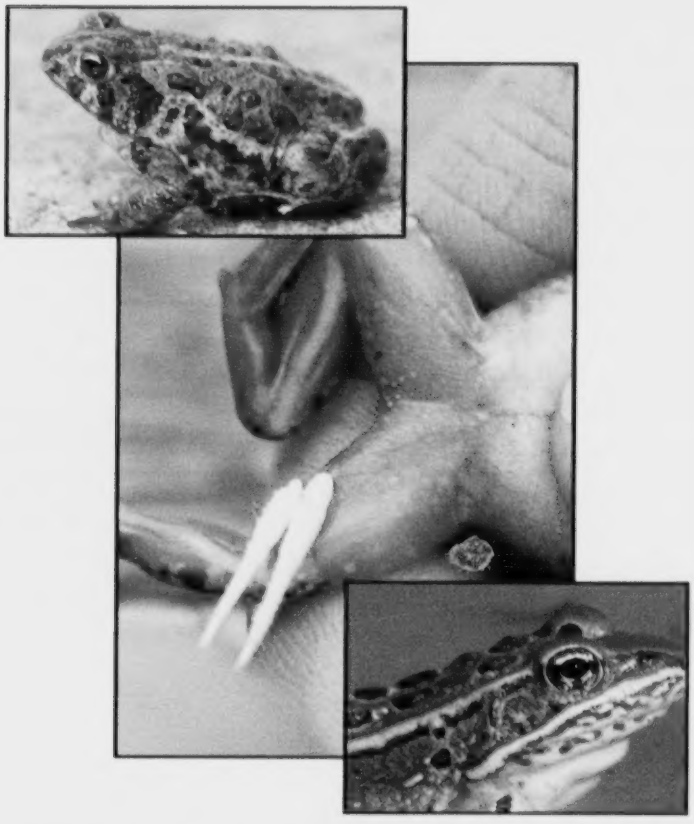
Occurrence and Prevalence of Chytrid Fungus (*Batrachochytrium dendrobatidis*) in Amphibian Species of Alberta



Alberta Species at Risk Report No. 143

Government of Alberta

Occurrence and Prevalence of Chytrid Fungus (*Batrachochytrium dendrobatidis*) in Amphibian Species of Alberta

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Alberta Species at Risk Report No. 143

March 2012

Government of Alberta
Sustainable Resource Development

Publication No.: I/597
ISBN: 978-1-4601-0030-1 (Printed Edition)
ISBN: 978-1-4601-0031-8 (Online Edition)
ISSN: 1496-7219 (Printed Edition)
ISSN: 1496-7146 (Online Edition)

Cover Photographs: D. Prescott

For copies of this report, contact:

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This publication may be cited as:

Stevens, S.D., D.R.C. Prescott, and D. P. Whiteside. 2012. Occurrence and Prevalence of Chytrid Fungus (*Batrachochytrium dendrobatidis*) in Amphibian Species of Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 143, Edmonton, AB. 24 pp.

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ACKNOWLEDGEMENTS

We thank the following partners for financially supporting the project: Alberta Parks and Protected Areas Cooperative Fund, North American Waterfowl Management Plan, Alberta Sport, Recreation, Parks and Wildlife Foundation, Alberta Sustainable Resource Development, Canadian Association of Zoos and Aquariums, and the Calgary Zoo. We also thank Alberta Tourism, Parks and Recreation, and their staff and operators for providing field accommodation. The project could not have been completed without the enthusiastic assistance from the following people and organizations: Des Smith and Breana Jones (Calgary Zoo); Vaughn Hauser and the Friends of Fish Creek; the Junior Forest Rangers (Hinton Branch); Barb Johnston, Dani Boutin, Cyndi Smith (Waterton Lakes National Park); Charlie Pacas (Banff National Park); Brenda Shepherd (Jasper National Park); Brian Eaton (Alberta Innovates Technology Futures); Gavin Berg, Brett Boukall, Danielle Cross, Robin Gutsell, Kari Hamilton, Ed Hofman, Cindy Kemper, Lisa Matthias, Bob McClymont, Paul MacMahon, Mike Russell, Reg Russell, Joel Nicholson, Kristina Nordstrom, Curtis Stratmoen, and Hugh Wollis (Alberta Sustainable Resource Development); Tangle Caron, Heidi Eijgel, Terry Krause, Cameron Lockerbie, Calvin McLeod, Donna McLean, Wayne Nordstrom, Anita Nelson, Ksenija Vujnovic (Alberta Tourism, Parks and Recreation); Shane Mascarin (CFB Wainwright), and too many other assistants and land-holders to name. Special thanks go to staff of the Alberta Conservation Association (Michelle Gordon, Sue Peters, Jen Stroh and Kelly Boyle) for collecting many of the northern leopard frog samples, and in particular to our colleague Kris Kendell for his participation in this and other amphibian projects, and for comments on the manuscript. The manuscript also benefited from comments by Margo Pybus (Alberta Sustainable Resource Development, Provincial Disease Specialist).

EXECUTIVE SUMMARY

Infectious diseases are one of a suite of factors implicated in the declines and extinctions of amphibians worldwide. *Batrachochytrium dendrobatidis* (*Bd*) is a fungus that colonizes amphibian skin and the associated disease, chytridiomycosis, can impair cutaneous respiration and osmoregulation and result in death of the host. This disease is the focus of many amphibian conservation efforts because of its nearly global distribution.

In Alberta, chytrid fungus was first observed in boreal toads and northern leopard frogs in 1999. In 2006, a pilot study found evidence of *Bd* at three of four sites occupied by northern leopard frogs, a *Threatened* species in Alberta. Sampling was expanded between 2007 and 2010 to sites across the province, and to as many amphibian species as possible. The presence of chytrid fungus was assessed by Polymerase Chain Reaction (PCR) of skin swabs that were analyzed in batches to maximize the likelihood of *Bd* detection. Based on published accounts of *Bd* detection elsewhere, we sought a minimum sample size of 60 individual amphibians at a site.

A total of 3,611 individuals of 8 species was sampled at 92 sites in Alberta between 2006 and 2010. Overall, *Bd* was detected at 44% of 92 sites, and in 22% of 670 species- and year-specific sample batches. Although the fungus was not detected at 51 sites (56%), sample sizes of 60 or more amphibians were only achieved at 17 of those, and thus only 18% of sites could be termed "chytrid free". Sites that were *Bd* positive had a higher number of individuals and batches tested than sites that were *Bd* negative. This suggests that additional sampling could have revealed more occurrences.

We detected chytrid fungus in all species tested, with the exception of Tiger Salamanders that had very small sample size (three individuals at a single site). We report the first detection of *Bd* in Canadian toads and long-toed salamanders, and the first occurrence in Alberta in boreal chorus frogs, Columbia spotted frogs, and wood frogs. Occurrence (% of sites infected) and prevalence (% of batches infected) of *Bd* differed significantly among species and were highest in wood frogs and lowest in northern leopard frogs. The overall prevalence of *Bd* differed among drainage basins, with the highest prevalence in the Athabasca, Peace, and North Saskatchewan River drainages. Among the four species with sufficient sample size to address possible drainage basin effects, only the boreal toad exhibited significant differences in prevalence among basins.

This study provides base-line data on the occurrence and prevalence of *Bd* in Alberta and can lead to more refined questions about the fungus and its' effects. We have no evidence of chytrid-associated population declines during the course of our study, and on only one occasion found amphibians that may have succumbed to chytridiomycosis. We recommend that future applied research in Alberta focus on potential population level effects for *At Risk*, *May Be At Risk*, and *Sensitive* species at sites where *Bd* is now known to occur so that the threat of *Bd* infection can be assessed and management priorities established.

INTRODUCTION

Amphibian species have been declining globally at an alarming rate. One-third of the approximately 6000 species are classified as threatened, up to 167 species may be extinct, and another 113 species have not been observed in recent years (NatureServe 2011). Infectious diseases are one of a suite of factors implicated in the declines and extinctions of amphibians worldwide. One such disease, chytridiomycosis, is caused by the chytrid fungus *Batrachochytrium dendrobatidis* (*Bd*) that colonizes amphibian skin and is spread by free-swimming zoospores (Berger et al. 1998, Nichols et al. 2001, Piotrowski et al. 2004). Chytrid zoospores have limited swimming ability (~ 2 cm) and the fungus appears to depend on water flow or host movement for long distance dispersal (Johnson and Speare 2005). Recent work suggests that *Bd* may produce non-pathogenic resting spores that attach to the amphibian skin surface, but without causing disease (Schloegel et al. 2006). *Bd* infection, however, can result in hyperkeratosis (a marked thickening of the *stratum corneum*) and excessive skin sloughing, which impair cutaneous respiration and osmoregulation and can result in death (Longcore et al. 1999). This disease is the focus of many amphibian conservation efforts because of its nearly global distribution (Green et al. 2002, Gascon et al. 2007, Skerrat et al. 2007), although how, and for how long, *Bd* came to be globally distributed is under investigation (e.g. Weldon et al. 2004, Ouellet et al. 2005). The impacts of chytridiomycosis differ substantially among amphibian species and populations. Some are unaffected by *Bd* infection and act as carriers of the fungus (e.g. bullfrogs, *Rana catesbeiana*; Daszak et al. 2004). Some species tolerate a chronic, low level of infection, or experience a relatively slow population decline (e.g. boreal toads, *Bufo boreas*; Briggs et al. 2010, Longo and Burrows 2010, Pilliod et al. 2010) and some species experience severe, high levels of infection and acute population decline (e.g. Panama poison dart frogs, *Colostethus panamensis*; Lips et al. 2006, Vredenburg et al. 2010). There is evidence that these severe outbreaks can lead to the collapse of entire amphibian faunas including regional and global extinction (e.g. Bob's robber frogs, *Craugastor punctariolus*; Schloegel et al. 2006, Ryan et al. 2008, Crawford et al. 2010). Factors leading to lethal chytriomycosis are not well understood, but ecological context, particularly climate, is critical (Pounds et al. 2006).

Chytrid fungus was discovered in Alberta in 1999 from necropsies of several specimens of boreal toads and northern leopard frogs (*Lithobates pipiens*) collected near Caroline (ASRD 2003). In late 2006, we conducted a pilot-study to determine whether *Bd* was present at northern leopard frog sites in southern Alberta. Despite small samples sizes, we detected *Bd* at 3 of 4 sites and collected several moribund individuals that were later found to have histological evidence of chytridiomycosis (Whiteside et al. 2007). The detection of *Bd* at multiple sites, and in a provincially *Threatened* species led to the expansion of *Bd* surveillance to other areas of the province, and to other amphibian species between 2007 and 2010. The results, reported herein, provide a base-line for the occurrence and prevalence of *Bd* in Alberta. This information is required for the effective conservation and management of a broad suite of amphibian species, many of which are of high conservation concern in Alberta (ASRD 2010).

METHODS

In 2007, sampling focused primarily at northern leopard frog sites found during a provincial survey in 2005 (Kendell et al. 2007). Limited opportunistic sampling of other species within northern leopard frog range also occurred. In 2008, study sites were expanded geographically to include additional amphibian species. Those sites were chosen based on other current amphibian research projects, or centred at or near provincial parks where logistical considerations (i.e. access, accommodations, local knowledge) and additional manpower were available. Sites were generally sampled on a single day, although occasionally were visited over several days and in multiple years to achieve desired sample sizes (see below). The bulk of sampling occurred during late July and August, when young-of-the-year amphibians were still located near breeding water bodies, and thus at relatively high densities.

Decontamination guidelines (bleaching of boots, nets and other equipment) were implemented throughout the course of the study to prevent the possible transmission of *Bd* from site to site by researchers. Site coordinates were recorded in decimal degress (NAD 83) on Garmin 12XL or 76CSX handheld GPS units. Amphibians were captured by hand or with small nets. Cross-contamination of sampled individuals was prevented by sterilizing nets (10% bleach) and changing gloves (powder-free nitrile) or washing hands with hypo-allergenic disinfectant soap between capture of each individual. A sterile polyester-tipped swab (UltraMicroPur™) was run five times along the webbing of feet (ventral and dorsal), and the ventral and lateral surfaces of the amphibian, and placed in a sterile 5 ml polystyrene vial (Whiteside et al. 2007). After swabbing, amphibians were released at the site of capture. All vials from a site were put in Whirlpak™ bags and stored on ice in a cooler until refrigerated. Staff at the Calgary Zoo conducted initial processing of samples, such as preparation of batch samples for analysis.

Presence of chytrid fungus from skin cells collected on swabs was assessed by real-time polymerase chain reaction (TaqMan PCR) at the British Columbia Animal Health Branch in Abbotsford following protocols established by Boyle et al. (2004). Samples were analyzed in batches to maximize the likelihood of disease detection (Boyle et al. 2004). In 2007, 1-57 swabs were batched prior to testing (Appendix 1). However, that protocol was refined from 2008 onwards, where five individual samples from a given species and location were combined to produce a batch sample (or less if fewer than five individuals of a species were captured) (Hyatt et al. 2007). The analysis of prevalence among individual amphibians was not financially feasible. Nevertheless, pooling of samples in batches of five provides an estimate of prevalence at a site.

A site is "positive" for *Bd* based on detection of a single infected individual. However, a site cannot be declared "negative" until a larger sample of individuals is tested. Previous prevalence studies from Australia and South Africa have shown infection rates up to 20%, but average between 2-10% (Stuart et al. 2004). Assuming a likelihood of detection of 95% with a prevalence of ≥5% at an infected site, a minimum number of amphibians to test at each site would be approximately 60 to confidently term a site "chytrid free" (Whiteside et al. 2007). We therefore strove to capture 60 amphibians at each site (occasionally on multiple visits or in different years) but recognized that this would not always be possible due to logistical constraints and low densities of amphibians at some sites. If a site was sampled in more than

one year, swabs were batched separately to allow possible comparison of *Bd* presence between years.

To present the most complete picture of the distribution and occurrence of *Bd* in Alberta, we included data from the four sites surveyed in the 2006 pilot study with data from the broader studies conducted from 2007–2010. We compared the number of amphibians collected and the number of batches tested at *Bd*-positive and *Bd*-negative sites using Mann–Whitney *U*-tests (Conover 1980). Two-tailed chi-square tests (Conover 1980) using GraphPad Software™ were used to compare the proportion of *Bd* positive sites (occurrence) and batches (prevalence) among species and drainage basins. In these analyses, the expected number of positives was calculated by multiplying the combined number of sites or batches within a species or drainage basin by the overall percentage of positives combined from all species or basins. To separate potential combined effects of species and drainage basin, we used two-tailed chi-square tests to compare the prevalence of *Bd* across basins separately for species with the largest sample sizes and geographic distribution of sites.

RESULTS

A total of 3,611 amphibians was sampled from 92 sites throughout Alberta between 2006 and 2010. This sample included eight species, differing in provincial status from *Threatened* to *Secure* (Figure 1, Table 1), from 14 of 21 Alberta drainage basins (Appendix 1). Northern leopard frogs and wood frogs (*Lithobates sylvaticus*) were the most common species sampled, representing 39% and 30% of the total, respectively (Table 1). The only Alberta amphibian species not represented in this study were the great plains toad (*Bufo cognatus*) and the plains spadefoot (*Spea bombifrons*). Sampling occurred as early as 15 July and as late as 17 October with 93% of visits occurring between 15 July and 30 August. A total of 16 sites was visited in multiple years, and 57 sites had multiple species sampled (range 1–3 species; Appendix 1).

The target of 60 samples was achieved at 40 of 92 sites (43%). PCR testing for the presence of *Bd* was conducted on 670 species- and year-specific batch samples (Appendix 1). Overall, *Bd* was detected at 41 of 92 sites (44%). Although the fungus was not detected at 51 sites (56%), a full sample ($n \geq 60$ individuals) was achieved at 17 of those, and thus only 17 of 92 (18%) sites can be termed "chytrid free" with a degree of certainty. Sites that were *Bd* positive had a higher number of amphibians collected (47.0 ± 4.7 [SE] versus 34.0 ± 3.7; Mann-Whitney $U=1290$, $p<0.05$) and batches tested (9.5 ± 0.9 versus 5.5 ± 0.6; Mann-Whitney $U=1463$, $p<0.01$) than sites that were *Bd* negative. Of the 670 pooled samples tested for *Bd*, 146 (22%) were positive for the fungus.

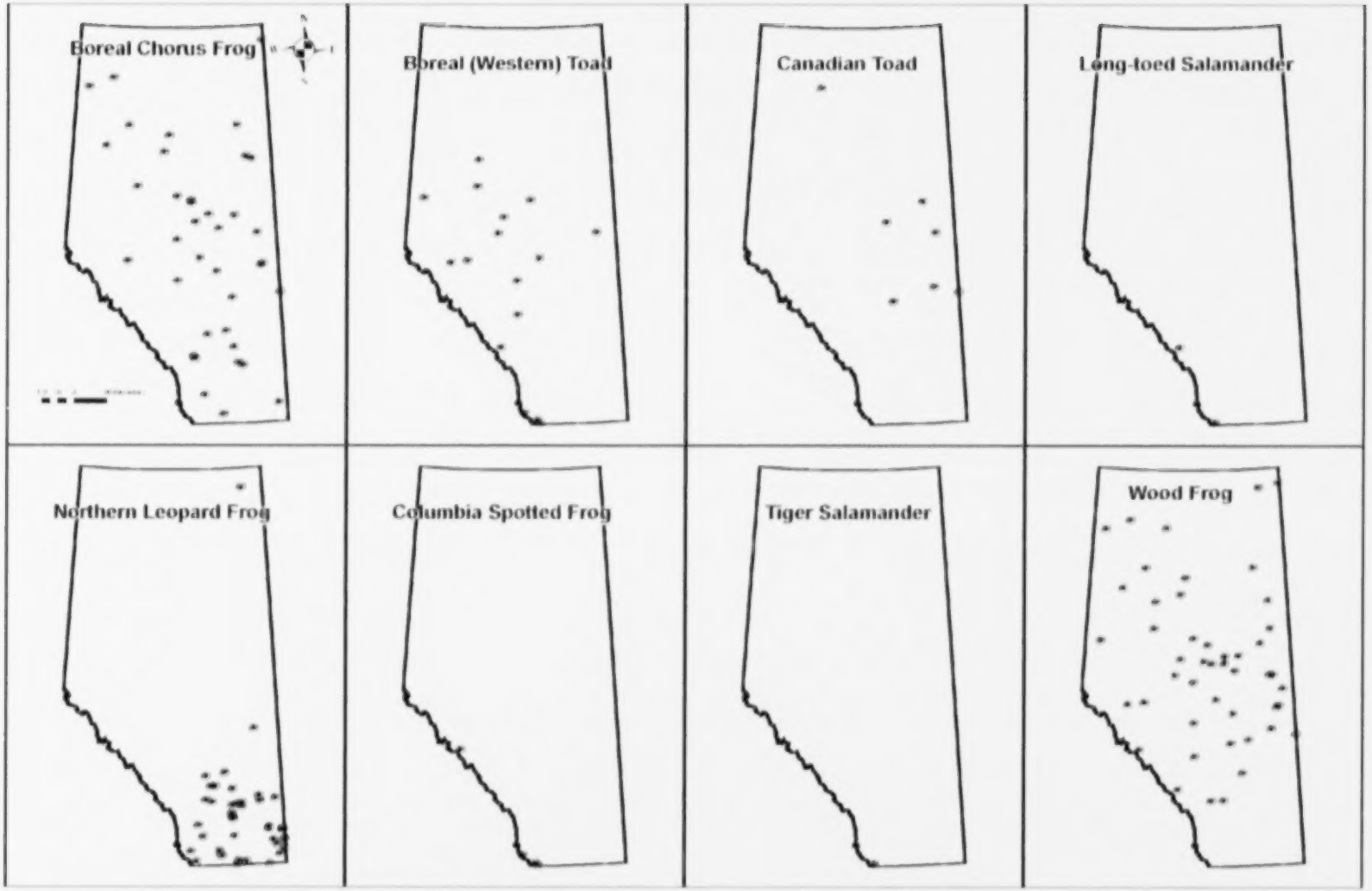

Figure 1. Geographic distribution of sampling locations for species involved in the study.

Table 1. Status listing and sample size of amphibians represented in the study.

Species	Status[1]	# 2006	# 2007	# 2008	# 2009/10	TOTAL
Northern Leopard Frog-NLFR (*Lithobates pipiens*)	At Risk	15	855	475	69	**1,414**
Canadian Toad-CATO (*Bufo hemiophrys*)	May be At Risk	–	3	149	–	**152**
Boreal Toad-BOTO (*Bufo boreas*)	Sensitive	–	–	208	10	**218**
Columbia Spotted Frog-SPFR (*Rana luteiventris*)	Sensitive	–	47	117	–	**164**
Long-toed Salamander-LTSA (*Ambystoma marodactylum*	Sensitive	–	–	80	–	**80**
Boreal Chorus Frog-BCFR (*Pseudacris maculate*)	Secure	–	55	362	60	**477**
Tiger Salamander-TISA (*Ambystoma tigrinum*)	Secure	–	–	3	–	**3**
Wood Frog-WOFR (*Rana sylvatica*)	Secure	–	35	997	71	**1,103**
TOTAL		**15**	**995**	**2,391**	**210**	**3,611**

[1] Current general status ranking in Alberta (ASRD 2010).

Detection of *Bd* at the site level showed significant difference among species (X^2=14.4, p<0.01). Although Columbia spotted frogs (*Rana luteiventris*) were only sampled at four locations, three tested positive for *Bd*. A similarly high percent of *Bd*-positive sites was detected in wood frogs (64%). Excluding tiger salamanders (*Ambystoma tigrinum*), where only one site was surveyed and *Bd* was not detected, northern leopard frogs had the lowest occurrence of *Bd* (16%) among sites. *Bd* was detected in 30% or more sites in which boreal chorus frogs (*Pseudacris maculata*), boreal toads, or Canadian toads (*Bufo hemophrys*) occurred. *Bd* was detected in long-toed salamanders (*Ambystoma macrodactylum*) at one of two sites sampled for that species (Figure 2). Prevalence of *Bd* in batches also showed significant difference among species (X^2=18.6, p<0.01) and similar trends to occurrence among sites. The highest prevalence for a species occurred in wood frogs, where 39% of batches tested positive. Prevalence was similar among boreal toads, long-toed salamanders, and Columbia spotted frogs (26%, 25%, and 27%, respectively; Figure 2). Prevalence was substantially lower in northern leopard frogs and Canadian toads (4% and 6%, respectively; Figure 2). Only northern leopard frogs were surveyed at the same site in multiple years. At two of 16 (13%) multiple-sampled sites, PCR results conflicted in separate years; one of those had only one batch tested in each of two years, while the other site had one of 22 batches (5%) test positive for *Bd*. The other 14 sites were negative in both years of sampling (Appendix 1). Full samples ($n \geq 60$) were achieved by combining years at 10 of the 16 (63%) multiple-sampled sites.

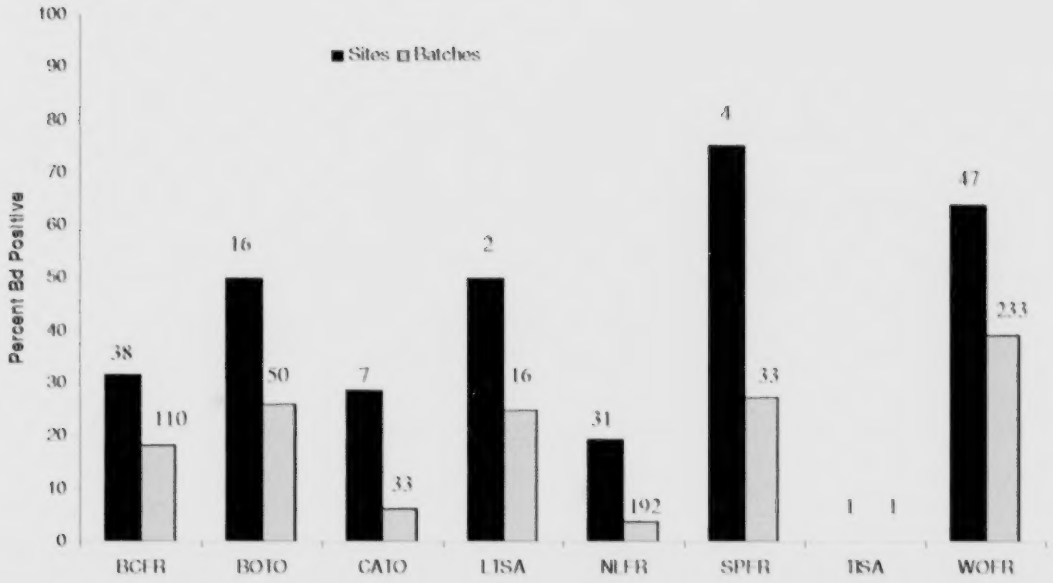

Figure 2. Percent of sites and batches in which a given species tested positive for *Batracochytrium dendrobatidis* (*Bd*) (sample size indicated above; see Table 1 for species acronyms).

Bd was widely distributed across Alberta (Figure 3), but was not detected in the Athabasca Lake, Hay River, Slave River or Sounding Creek basins where sample sizes were very low (1-2 sites/basin). There was no difference among drainages in terms of the occurrence of positive sites (X^2=8.0, p>0.3). However, there was a significant difference among basins in the prevalence of *Bd* positive batches (X^2=51.9, p<0.01), with the highest values occurring in the Athabasca River, Peace River and North Saskatchewan River basins (42%, 31% and 30%, respectively; Figure 4). The lowest prevalence of *Bd* occurred in the Red Deer River, South Saskatchewan River and Milk River basins (5%, 7%, and 8%, respectively; Figure 4). *Bd* prevalence did not differ significantly among drainages for three of the most common and widely distributed species in our samples (boreal chorus frog: X^2=5.9, p>0.4; northern leopard frog: X^2=3.8, p>0.5; wood frog: X^2=10.3, p>0.1). However, differences among drainages were significant for boreal toads (X^2=11.5, p<0.05), with high prevalence occurring in the Bow, Oldman and Athabasca River drainages (100%, 56% and 40%, respectively; Figure 5).

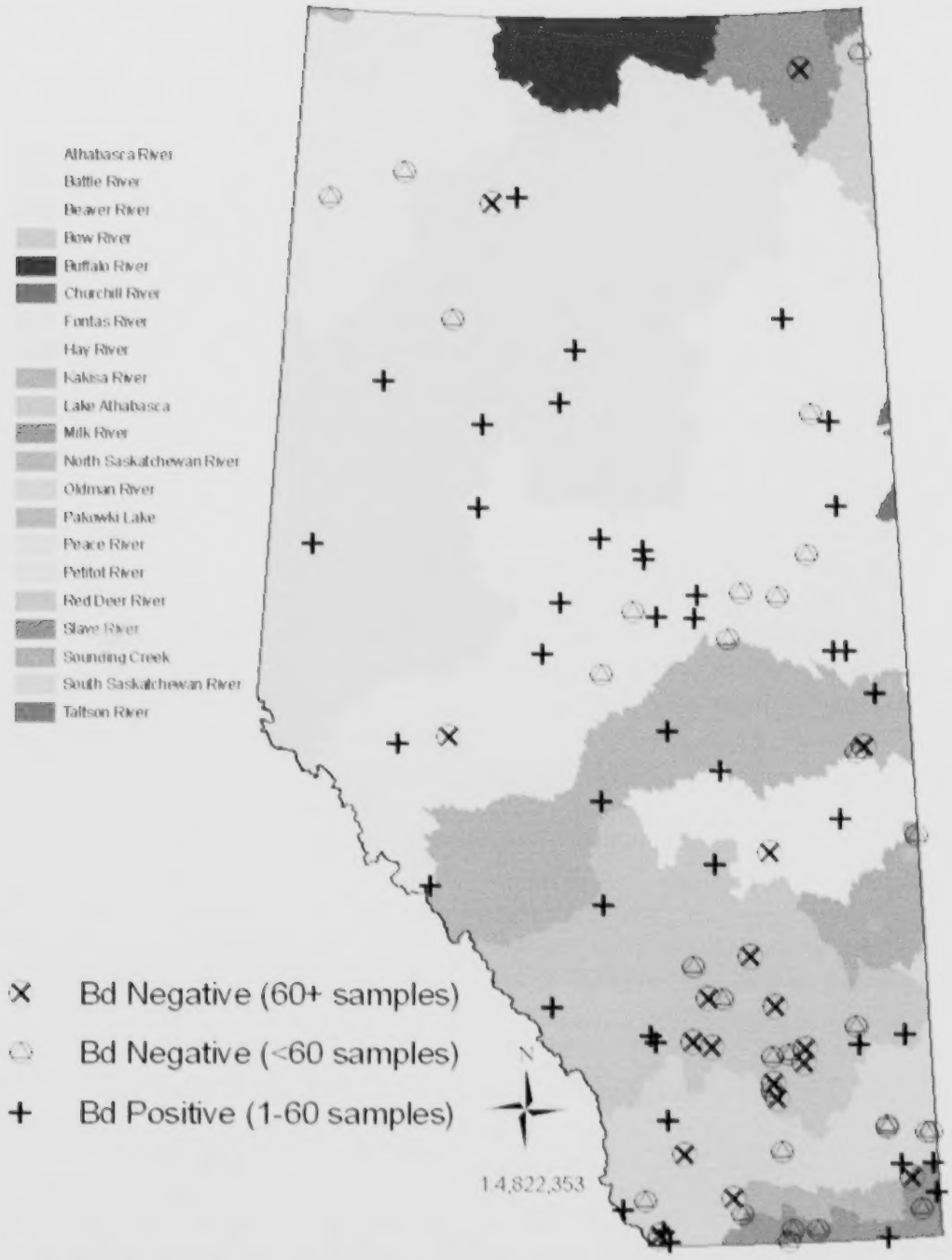

Figure 3. Map of *Bd* PCR test results by river basin in Alberta, 2006-2010.

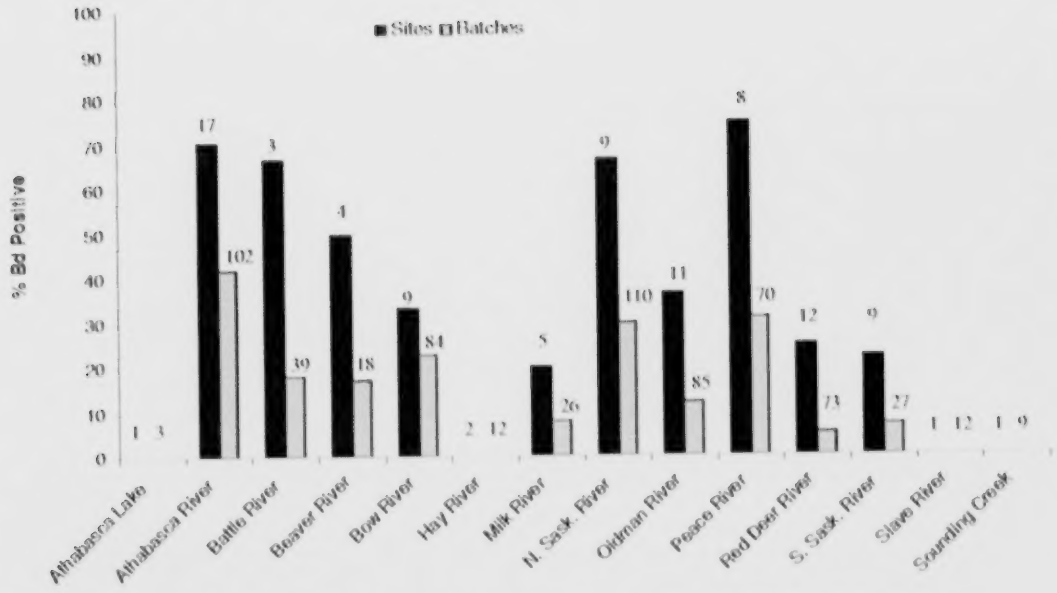

Figure 4. Percent of sites and batches positive for *Bd* by drainage basin (sample size indicated above).

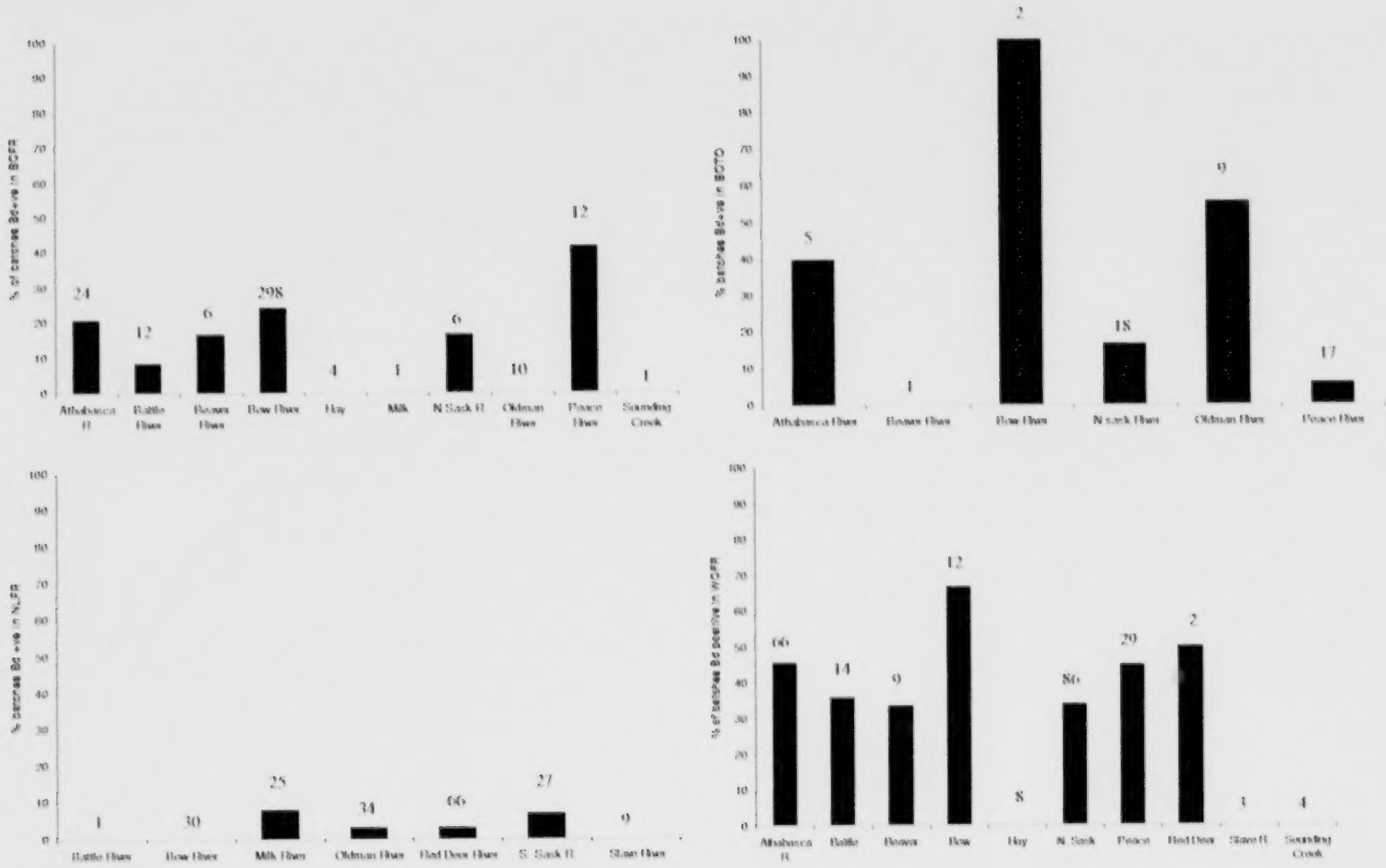

Figure 5. Percent of batches positive for *Bd* in boreal chorus frogs (BCFR), boreal toads (BOTO), northern leopard frogs (NLFR), and wood frogs (WOFR) by drainage basin (number of batches tested indicated above).

DISCUSSION

Our study represents the first province-wide surveillance for *Bd* conducted in Canada, and shows the fungus to be widely distributed and in a broad range of amphibian species in Alberta. As of 2009, a global database for results of PCR and clinical *Bd* tests showed only 219 positive cases in Canada, with none noted for Alberta (Bd-Maps.Net, *accessed* January 2012). As such, our work fills a major gap in knowledge of the global distribution of this pathogen. The presence and widespread occurrence of chytrid in Alberta should come as no surprise, as *Bd* has recently been shown to occur in many areas of western North America, including Alaska (Reeves 2008), British Columbia (Deguise and Richardson 2009, Voordouw et al. 2010), the Northwest Territories (Schock et al. 2010), Colorado, Wyoming, Montana and Idaho (Muths et al. 2008) and Oregon and Washington (Pearl et al. 2009). Most species found to carry the fungus in Alberta have also been shown to be *Bd* positive elsewhere in their range, including the wood frog (Ouellet et al. 2005, Longcore et al. 2007, Young et al. 2007, Reeves 2008, Schock et al. 2010), boreal toad (Young et al. 2007, Deguise and Richardson 2008, Schock et al. 2010), northern leopard frog (Longcore et al. 2007, Woodhams et al. 2008, Voorduow et al. 2010), and boreal chorus frog (*Pseudacris sp.*: Green and Muths 2005, Young et al. 2007). Our study documents the first reported evidence of *Bd* in Canadian toads and long-toed salamanders and the first evidence in Alberta for boreal chorus frogs, Columbia spotted frogs, and wood frogs.

We found *Bd* occurred at 44% of the sites surveyed in the province, with a prevalence of 22% of tested batches. These are undoubtedly conservative estimates, because only 18% of sites had a complete ($n > 60$; Whiteside et al. 2007) sample and can be considered "chytrid free". Furthermore, *Bd*-positive sites had a higher number of individuals (and batches tested) than *Bd*-negative sites, suggesting that increased sampling effort would have revealed additional *Bd*-positive sites in the province. Other geographically wide-ranging multi-species studies in North America reported occurrences of 3% (Northwest Territories; Schock et al. 2010), 64% (Colorado, Wyoming, Montana, Idaho; Muths et al. 2008), and in six of ten states in south-eastern United States (Rothermel et al. 2008). Ouellet et al. (2005) reported that 43% of sites in Quebec were infected, with a prevalence of 18%. However, it is difficult to make direct comparisons of occurrence and prevalence between studies because of differences in timing, species and age class composition, sampling effort and analytical and other methods. For example, *Bd* may be less prevalent in the summer than in the spring and fall (Bradley et al. 2002, Kriger et al. 2007, Muths et al. 2008). However, this seasonality can be due to geographically influenced temperatures as a recent study found infection rates to be negatively correlated with water temperature (Forrest and Schlaepfer 2011). Many studies use PCR tests on swabs from individual amphibians (Schock et al. 2010, Voorduow et al. 2010) as opposed to batch samples as reported here. It has also been suggested that the more times a swab is run along the skin of an amphibian the greater the likelihood of detection (Voorduow et al. 2010) and that age classes may differ in their susceptibility to *Bd* (Briggs et al. 2005, Voorduow et al. 2010). Finally, there may be annual differences in the occurrence or prevalence of *Bd* at a site, which may be difficult to distinguish from seasonal or species effects if timing of sampling or species compositions differ among years. In our study, most of the small number of sites that were tested in consecutive years showed consistent results (all negative). However, two were positive in one year and negative in a succeeding year (although one of them had only one batch tested in each year). At 'Prince Springs' *Bd* was

detected in PCR results from a small sample and histological evidence of infection was observed in 2006 (Whiteside et al. 2007). Combined results from 2007 and 2010 were negative in 21 batches (105 swabs). Since samples from 2006 were collected in mid-October, while samples from 2007 and 2010 were collected in July and August, a seasonal effect on *Bd* detection seems likely. Standardized protocols for surveillance of *Bd* would better enable comparisons of occurrence and prevalence both within species, and among geographic locations (Skerratt et al. 2008).

We found that occurrence and prevalence of *Bd* differed among species, being highest in wood frogs and lowest in northern leopard frogs (occurrence was 75% in Columbia spotted frogs, but only 4 sites were sampled). The 39% prevalence in wood frogs reported here is substantially higher than the 3% reported from the Northwest Territories (Schock et al. 2010). While that difference may be in part due to methodological differences between studies, it may also be due to degradation of samples that resulted in false negatives from the Territories (Schock et al. 2010). However, it is also possible that *Bd* has had a more recent arrival in the far north (Schock et al. 2010), and has limited occurrence in the environment. In northern leopard frogs, the 4% prevalence reported here is substantially lower than the 13% reported for a re-introduced population in southwestern British Columbia (Voordouw et al. 2010), although the prevalence of *Bd* in that population has stabilized and may be decreasing (Voordouw et al. 2010). The 26% prevalence we determined for boreal toads is comparable to 28% observed in that species from southwestern British Columbia (Deguise and Richardson 2009).

Other studies have reported geographic trends in *Bd* prevalence as a function of latitude (Krieger et al. 2007), elevation, and temperature (Muths et al. 2008). We found some evidence of geographical variability in the prevalence of *Bd* when results were portioned by drainage basin. However, that difference is likely to be related to different levels of *Bd* detection in species that have different geographical ranges (see ASRD 2009 for geographic ranges of amphibians in Alberta). For example, lower prevalence of *Bd* in southern drainages could be explained by low prevalence in northern leopard frogs, and a high prevalence in more northern drainages could be explained by high *Bd* prevalence in wood frogs. That the highest incidence of infection for wood frogs and boreal toads occurred in the Bow River drainage may suggest a higher overall presence of *Bd* in that basin. However, it is notable that northern leopard frogs had their lowest level of infection in the Bow River drainage, possibly indicating resistance to *Bd* (see below).

Chytrid fungus has been implicated in population declines of amphibians in many areas of the world (Berger et al. 1998, Hero and Morrison 2004, Lips et al. 2006, Schloegel et al. 2006, Ryan et al. 2008, Crawford et al. 2010). However, like many other studies in North America (Rothermel et al. 2008, Schock et al. 2010, Voordouw et al. 2010), we have no evidence of chytrid-associated population declines in Alberta during the time frame of this study, and on only one occasion found amphibians that may have succumbed to chytridiomycosis. Nevertheless, chytrid-associated population declines of species that occur in Alberta have been noted in other areas (e.g., boreal toad and northern leopard frog in Colorado; Carey et al. 1999, Muths et al. 2003, Murphy et al. 2009, Pilliod et al. 2010), suggesting that similar declines could potentially occur here. It is also important to consider that *Bd* has been shown to have sub-lethal effects, such as thermoregulatory and other alterations of host behaviour (Retallick and Miera 2004, Richards-Zawacki 2009), that would be extremely difficult to

detect in the field, but that could nevertheless result in population declines. We can therefore not dismiss the possibility that chytrid may be, in part, responsible for the apparent declines of some amphibian species in the province, including the possibility that it may have contributed to rapid population declines in the northern leopard frog in the 1970s and 1980s (Carey et al. 1999, Kendell et al. 2007). The low occurrence and prevalence of *Bd* found in northern leopard frogs in this study may be evidence that populations have developed resistance to the disease over time. Such resistance has been indicated in wild (Voordouw et al. 2010) and captive (Woodhams et al. 2008) northern leopard frogs, and has been suggested for a variety of species (Daszak et al. 2004, Ardipradja et al. 2007, Woodhams et al. 2010).

Conservation priorities and mitigation strategies for amphibians threatened by chytridiomycosis are currently structured primarily around preventing pathogen spread and developing treatment or remedial disease strategies (Woodhams et al. 2011). However, elimination of *Bd* is not necessarily the desired management endpoint for the purposes of amphibian conservation because preventing disease does not always require eliminating exposure to pathogens, and preventing population declines does not necessarily require eliminating disease (Woodhams et al. 2011). While a "Threat Abatement Plan" for chydridiomycosis is appropriate in Australia (Australian Department of the Environment and Heritage 2006) where pronounced amphibian population declines have been attributed to the disease (Berger et al. 1998, Hero and Morrison 2004), such a strategy may not be appropriate in Alberta until population effects are documented. We recommend that future research in Alberta focus on potential population-level effects for *At Risk*, *May Be At Risk*, and *Sensitive* species at sites where *Bd* is now known to occur so that the threat of *Bd* infection can be assessed and management priorities established.

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APPENDIX

Locations and results of chytrid testing by species in Alberta, 2006-2010.

DRAINAGE	SITE	YEAR	LATITUDE	LONGITUDE	SPECIES	#Individuals	# Batches	# Positives
ATHABASCA LAKE	COLIN LAKE	2008	59.592	-110.078	BCFR	1	1	0
ATHABASCA LAKE	COLIN LAKE	2008	59.592	-110.078	WOFR	9	2	0
ATHABASCA RIVER	CHARON LAKE REC. AREA	2008	54.834	-112.523	WOFR	1	1	0
ATHABASCA RIVER	CHRYSTINA LAKE	2008	54.764	-115.345	BOTO	3	1	1
ATHABASCA RIVER	CHRYSTINA LAKE	2008	54.764	-115.345	WOFR	57	12	3
ATHABASCA RIVER	COLLINGTON	2008	54.618	-113.250	CATO	2	1	0
ATHABASCA RIVER	COLLINGTON	2008	54.618	-113.250	WOFR	11	3	2
ATHABASCA RIVER	CONKLIN LAKE	2008	55.569	-110.937	WOFR	4	1	1
ATHABASCA RIVER	CROSS LAKE PP	2008	54.632	-113.837	BCFR	1	1	1
ATHABASCA RIVER	CROSS LAKE PP	2008	54.632	-113.837	WOFR	1	1	1
ATHABASCA RIVER	FAWCETT CREEK	2008	55.232	-114.056	BCFR	1	1	0
ATHABASCA RIVER	FAWCETT CREEK	2008	55.232	-114.056	BOTO	1	1	1
ATHABASCA RIVER	FLAT BUSH	2008	54.689	-114.224	WOFR	1	1	0
ATHABASCA RIVER	FORT MACMURRAY	2008	56.406	-111.298	BCFR	1	1	0
ATHABASCA RIVER	FORT MCKAY "A"	2008	57.266	-111.674	BCFR	1	1	1
ATHABASCA RIVER	FORT MCKAY "A"	2008	57.266	-111.674	WOFR	59	12	4
ATHABASCA RIVER	JASPER	2009	52.215	-117.236	SPFR	44	9	6
ATHABASCA RIVER	JASPER	2009	52.215	-117.236	WOFR	16	4	2
ATHABASCA RIVER	JUMPING DEER LAKE	2008	54.824	-113.210	BCFR	1	1	0
ATHABASCA RIVER	JUMPING DEER LAKE	2008	54.824	-113.210	WOFR	9	2	2
ATHABASCA RIVER	KINOSIS LAKE	2008	56.330	-110.981	BCFR	3	1	0
ATHABASCA RIVER	KINOSIS LAKE	2008	56.330	-110.981	WOFR	57	12	8
ATHABASCA RIVER	PICHE RIVER	2008	55.154	-111.466	CATO	1	1	0
ATHABASCA RIVER	PICHE RIVER	2008	55.154	-111.466	WOFR	1	1	0
ATHABASCA RIVER	SLAVE LAKE	2008	55.339	-114.723	BCFR	4	1	0
ATHABASCA RIVER	SLAVE LAKE	2008	55.339	-114.723	WOFR	10	2	2
ATHABASCA RIVER	SMITH	2008	55.151	-114.026	BCFR	59	12	1
ATHABASCA RIVER	SMITH	2008	55.151	-114.026	WOFR	1	1	0
ATHABASCA RIVER	THUNDER LAKE	2008	54.129	-114.727	BCFR	6	2	0

DRAINAGE	SITE	YEAR	LATITUDE	LONGITUDE	SPECIES	#Individuals	# Batches	# Positives
ATHABASCA RIVER	THUNDER LAKE	2008	54.129	-114.727	WOER	8	2	0
ATHABASCA RIVER	WINAGAMI PP	2008	55.607	-116.675	BCFR	14	3	2
ATHABASCA RIVER	WINAGAMI PP	2008	55.607	-116.675	BOTO	1	1	0
ATHABASCA RIVER	WINAGAMI PP	2008	55.607	-116.675	WOER	45	9	5
BATTLE	BIG KNIFE PP	2008	52.492	-112.211	BCFR	51	11	0
BATTLE	BIG KNIFE PP	2008	52.492	-112.211	WOER	9	2	0
BATTLE	MIQUELON LAKES PP	2008	53.243	-112.909	BCFR	5	1	1
BATTLE	MIQUELON LAKES PP	2008	53.243	-112.909	WOER	55	11	5
BATTLE	WAINWRIGHT	2008	52.783	-111.136	CATO	60	12	1
BATTLE	WAINWRIGHT	2008	52.783	-111.136	NLFR	1	1	0
BATTLE	WAINWRIGHT	2008	52.783	-111.136	WOER	4	1	0
BEAVER	LAC LA BICHE	2008	54.782	-111.966	BCFR	5	1	0
BEAVER	LONG LAKE PP	2008	54.424	-112.752	BCFR	17	4	0
BEAVER	LONG LAKE PP	2008	54.424	-112.752	WOER	9	2	0
BEAVER	MINNIE LAKE	2008	54.278	-111.104	WOER	1	1	1
BEAVER	MOOSE LAKE	2008	54.271	-110.918	BCFR	2	1	1
BEAVER	MOOSE LAKE	2008	54.271	-110.918	BOTO	1	1	0
BEAVER	MOOSE LAKE	2008	54.271	-110.918	CATO	7	2	0
BEAVER	MOOSE LAKE	2008	54.271	-110.918	WOER	26	6	2
BOW	ARROW WOOD	2007	50.770	-113.131	NLFR	18	1	0
BOW	BANFF NP	2008	51.146	-115.413	BOTO	10	2	2
BOW	BANFF NP	2008	51.146	-115.413	LTSA	55	11	2
BOW	BANFF NP	2008	51.146	-115.413	WOER	41	9	7
BOW	BOW CITY	2007	50.434	-112.268	NLFR	60	1	0
BOW	BOW CITY	2010	50.434	-112.268	NLFR	5	1	0
BOW	DEVON	2009	50.827	-113.924	BCFR	60	12	6
BOW	DEVON	2009	50.827	-113.924	WOER	5	1	1
BOW	DRAIN K	2007	50.289	-112.208	NLFR	16	1	0
BOW	DRAIN K	2008	50.289	-112.208	NLFR	44	9	0
BOW	DRAIN K	2010	50.289	-112.208	NLFR	5	1	0
BOW	FISH CREEK PP	2008	50.890	-114.002	BCFR	62	13	1
BOW	LONESOME LAKE	2007	50.367	-112.283	NLFR	5	1	0
BOW	ONE TREE	2007	50.609	-111.827	BCFR	49	4	0
BOW	ONE TREE	2007	50.609	-111.827	NLFR	46	4	0

DRAINAGE	SITE	YEAR	LATITUDE	LONGITUDE	SPECIES	#Individuals	# Batches	# Positives
BOW	WYNDHAM-CARSELAND PP	2008	50.825	-113.400	NLFR	54	11	0
BOW	WYNDHAM-CARSELAND PP	2008	50.825	-113.400	WOFR	6	2	0
HAY	HIGH LEVEL "A"	2008	58.589	-118.104	BCFR	11	3	0
HAY	HIGH LEVEL "A"	2008	58.589	-118.104	WOFR	10	2	0
HAY	RAINBOW LAKE	2008	58.317	-119.370	BCFR	1	1	0
HAY	RAINBOW LAKE	2008	58.317	-119.370	WOFR	30	6	0
MILK	HILWIGS	2007	49.106	-111.708	NLFR	1	1	0
MILK	KENNEDY COULEE	2008	49.006	-110.729	NLFR	60	13	2
MILK	MICHELLE RESERVOIR	2008	49.534	-110.378	BCFR	1	1	0
MILK	MICHELLE RESERVOIR	2007	49.534	-110.378	NLFR	42	1	0
MILK	MICHELLE RESERVOIR	2008	49.534	-110.378	NLFR	18	4	0
MILK	MILK RIVER	2007	49.119	-112.054	NLFR	20	1	0
MILK	MILK RIVER	2008	49.119	-112.054	NLFR	4	1	0
MILK	RED CREEK	2008	49.017	-112.105	NLFR	17	4	0
N SASK	BIG LAKE PP	2008	53.618	-113.696	BCFR	9	2	1
N SASK	BIG LAKE PP	2008	53.618	-113.696	BOTO	3	1	0
N SASK	BIG LAKE PP	2008	53.618	-113.696	WOFR	48	10	4
N SASK	BUCK LAKE	2008	52.988	-114.716	BCFR	1	1	0
N SASK	BUCK LAKE	2008	52.988	-114.716	BOTO	3	1	1
N SASK	BUCK LAKE	2008	52.988	-114.716	WOFR	56	12	3
N SASK	CARSON PEGASUS PP	2008	54.309	-115.631	BOTO	3	1	0
N SASK	CARSON PEGASUS PP	2008	54.309	-115.631	WOFR	57	12	9
N SASK	NICHOLS POND	2008	53.878	-110.512	WOFR	60	12	1
N SASK	OBED LAKE	2008	53.541	-117.044	BCFR	4	1	0
N SASK	OBED LAKE	2008	53.541	-117.044	BOTO	49	10	0
N SASK	OBED LAKE	2008	53.541	-117.044	WOFR	12	3	0
N SASK	PEARMAN POND	2008	53.408	-110.720	BCFR	4	1	0
N SASK	PEARMAN POND	2008	53.408	-110.720	WOFR	56	12	0
N SASK	RAVEN	2010	52.059	-114.686	BOTO	10	2	2
N SASK	RAVEN	2010	52.059	-114.686	WOFR	50	10	10
N SASK	VERMILLION LAKE PP	2008	53.365	-110.855	BCFR	1	1	0
N SASK	VERMILLION LAKE PP	2008	53.365	-110.855	WOFR	2	1	0
N SASK	WA SWITZER PP	2008	53.472	-117.795	BOTO	12	3	0
N SASK	WA SWITZER PP	2008	53.472	-117.795	WOFR	67	14	2

DRAINAGE	SITE	YEAR	LATITUDE	LONGITUDE	SPECIES	#Individuals	# Batches	# Positives
OLDMAN	BEAUVAIS LAKE PP	2009	49.406	-114.095	NLFR	49	10	0
OLDMAN	DIMM'S RANCH	2008	49.811	-113.534	BCFR	34	7	0
OLDMAN	DIMM'S RANCH	2007	49.811	-113.534	NLFR	24	2	0
OLDMAN	DIMM'S RANCH	2008	49.811	-113.534	NLFR	3	1	0
OLDMAN	MAGRATH	2007	49.408	-112.870	NLFR	48	4	0
OLDMAN	MAGRATH	2008	49.408	-112.870	NLFR	12	3	0
OLDMAN	TABER	2007	49.817	-112.167	NLFR	5	1	0
OLDMAN	TAYLOR FARMS	2008	49.269	-112.752	BCFR	12	3	0
OLDMAN	TAYLOR FARMS	2007	49.269	-112.752	NLFR	42	2	0
OLDMAN	TAYLOR FARMS	2008	49.269	-112.752	NLFR	2	1	0
OLDMAN	WEST CASTLE	2008	49.323	-114.401	BOTO	14	3	3
OLDMAN	WEST CASTLE	2008	49.323	-114.401	SPFR	25	5	2
OLDMAN	WILLOW CREEK PP	2006	50.129	-113.757	NLFR	2	1	1
OLDMAN	WATERTON LAKES NP "A"	2008	49.094	-113.887	SPFR	60	12	0
OLDMAN	WATERTON LAKES NP "B"	2008	49.127	-113.844	BOTO	19	4	2
OLDMAN	WATERTON LAKES NP "B"	2007	49.127	-113.844	NLFR/SPFR	52	2	1
OLDMAN	WATERTON LAKES NP "B"	2008	49.127	-113.844	NLFR	41	9	0
OLDMAN	WATERTON LAKES NP "C"	2008	49.033	-113.752	BOTO	10	2	0
OLDMAN	WATERTON LAKES NP "C"	2008	49.033	-113.752	SPFR	32	7	1
OLDMAN	WATERTON LAKES NP "D"	2008	49.062	-113.906	LTSA	25	5	0
OLDMAN	WATERTON LAKES NP "D"	2008	49.062	-113.906	TISA	3	1	0
PEACE	FORT VERMILLION	2008	58.392	-116.151	WOFR	1	1	1
PEACE	LOON LAKE	2008	56.560	-115.389	BCFR	13	3	2
PEACE	LOON LAKE	2008	56.560	-115.389	WOFR	7	2	1
PEACE	MACHESIS LAKE	2008	58.325	-116.580	CATO	60	12	0
PEACE	NOTIKEWIN	2008	57.279	-117.185	BCFR	1	1	0
PEACE	NOTIKEWIN	2008	57.279	-117.185	WOFR	5	1	0
PEACE	PEACE RIVER 1 "A"	2008	56.346	-116.635	BOTO	18	4	1
PEACE	PEACE RIVER 1 "A"	2008	56.346	-116.635	WOFR	27	6	2
PEACE	PEACE RIVER 2 "B"	2008	56.706	-118.291	BCFR	32	7	2
PEACE	PEACE RIVER 2 "B"	2008	56.706	-118.291	WOFR	30	6	6
PEACE	SASKATOON MOUNTAIN	2008	55.222	-119.286	BOTO	61	13	0
PEACE	SASKATOON MOUNTAIN	2008	55.222	-119.286	WOFR	4	1	1
PEACE	WABASCA RIVER	2008	57.023	-115.137	BCFR	2	1	1

DRAINAGE	SITE	YEAR	LATITUDE	LONGITUDE	SPECIES	#Individuals	# Batches	# Positives
PEACE	WABASCA RIVER	2008	57.023	-115.137	WOER	60	12	5
RED DEER	BUFFALO LAKE	2007	52.412	-113.016	CATO	3	1	1
RED DEER	BUFFALO LAKE	2007	52.412	-113.016	WOER	35	1	1
RED DEER	FINNIGAN FERRY	2007	51.116	-112.204	BCFR	1	1	0
RED DEER	FINNIGAN FERRY	2007	51.116	-112.204	NLFR	59	3	0
RED DEER	FINNIGAN FERRY	2010	51.116	-112.204	NLFR	5	1	0
RED DEER	GRAINGER DAM	2007	51.493	-113.384	BCFR	4	1	0
RED DEER	GRAINGER DAM	2007	51.493	-113.384	NLFR	28	3	0
RED DEER	JENNER	2006	50.756	-111.011	NLFR	4	1	1
RED DEER	JENNER	2007	50.756	-111.011	NLFR	7	1	0
RED DEER	MICHICHI	2007	51.578	-112.535	BCFR	1	1	0
RED DEER	MICHICHI	2007	51.578	-112.535	NLFR	32	1	0
RED DEER	MICHICHI	2008	51.578	-112.535	NLFR	48	10	0
RED DEER	MICHICHI	2008	51.578	-112.535	WOER	4	1	0
RED DEER	MILLICENT	2007	50.724	-111.794	NLFR	32	1	0
RED DEER	MILLICENT	2008	50.724	-111.794	NLFR	28	6	0
RED DEER	PRINCE SPRINGS	2006	50.816	-110.349	NLFR	6	1	1
RED DEER	PRINCE SPRINGS	2007	50.816	-110.349	NLFR	100	20	0
RED DEER	PRINCE SPRINGS	2010	50.816	-110.349	NLFR	5	1	0
RED DEER	ROCK LAKE	2008	50.691	-112.033	BCFR	1	1	0
RED DEER	ROCK LAKE	2008	50.691	-112.033	NLFR	7	2	0
RED DEER	SERVICEBERRY	2007	51.208	-113.169	NLFR	60	1	0
RED DEER	SEVERN DAM	2006	51.209	-112.963	NLFR	3	1	0
RED DEER	SEVERN DAM	2007	51.209	-112.963	NLFR	4	2	0
RED DEER	SNAKE LAKE	2008	50.669	-112.264	NLFR	45	9	0
RED DEER	VBARV RANCH	2007	50.919	-111.055	NLFR	17	2	0
S SASK	BATTLE CREEK	2007	49.397	-110.036	NLFR	19	1	1
S SASK	BROST	2007	49.937	-110.143	NLFR	26	2	0
S SASK	BROST	2008	49.937	-110.143	NLFR	16	4	0
S SASK	BARE CREEK	2007	49.250	-110.252	NLFR	1	1	0
S SASK	BULLSHEAD RESERVOIR	2007	49.667	-110.500	NLFR	57	2	1
S SASK	CYPRESS HILLS PP "A"	2007	49.662	-110.059	NLFR	36	5	0
S SASK	CYPRESS HILLS PP "B"	2007	49.660	-110.037	NLFR	26	3	0
S SASK	KIN COULEE	2007	50.015	-110.683	NLFR	13	2	0

DRAINAGE	SITE	YEAR	LATITUDE	LONGITUDE	SPECIES	#Individuals	# Batches	# Positives
S SASK	KINGSLAND	2007	49.991	-110.687	NLFR	11	1	0
S SASK	WALSH	2008	49.938	-110.074	NLFR	30	6	0
SLAVE	BOCQUENE LAKE	2008	59.476	-111.151	NLFR	45	9	0
SLAVE	BOCQUENE LAKE	2008	59.476	-111.151	WOFR	15	3	0
SOUNDING CREEK	DILLBERRY LAKE PP	2008	52.584	-110.022	BCFR	1	1	0
SOUNDING CREEK	DILLBERRY LAKE PP	2008	52.584	-110.022	CATO	19	4	0
SOUNDING CREEK	DILLBERRY LAKE PP	2008	52.584	-110.022	WOFR	21	4	0

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